Date: September 6, 2019

To: Ms. Fenix Grange, Ms. Lene Ichinotsubo &Mr. Robert Whittier, Hawaii DOH
Dr. Donald Thomas, University of Hawaii, Ocean and Earth Science and Technology

From: G.D. Beckett, RG, CHG, **AQUI-VER, INC.** (AVI)

DRAFT: PROPOSED APPROACH TO BOUND POTENTIAL LNAPL SOURCE TERMS AT THE NAVY RED HILL FACILITY

PROBLEM STATEMENT

The LNAPL source term needs to account for the current and potential future distributions of that source as it relates to potential risk to the groundwater system and receptors within it. If potential future distributions suggest a credible risk, then the rates of that LNAPL movement will also become important. That transport, if driven by high release rates/volumes, will potentially exceed groundwater flow velocities by 2 to 3 orders of magnitude and transient aspects of mitigation (like hydraulic capture) will need to be carefully considered. Conversely, if conservative LNAPL source terms defined as a function of potential release volumes do not pose a likely risk to receptors, then rates and transient aspects are likely not critically important.

Neither site data nor the Navy's proposed LNAPL modeling approach can conservatively demonstrate the representative current or past maximum extent of LNAPL in the aquifer resulting from the cumulative releases over the history of site operations beginning around1942. Operational and environmental data, when combined, indicate that all tanks have likely had releases with the exception of Tank 18. However, recently elevated vapor concentrations beneath that Tank may suggest a potential release issue there as well, though unconfirmed at this point. The recorded cumulative volume released to date is 194,581 gallons based on Navy reporting, but most of the known or suspected releases have no estimated release volume associated with them. Based on experience in estimating release volumes across the U.S., it is common for fuel facilities of this age and capacity to have experienced releases in the millions of gallons. However, whether this facility is comparable is not known at present and there may be release buffering associated with the tank concrete vaulting (though unproven at this time). There are two-wells within the 20-tank footprint (RHMW02 & -03) and one about 200-ft down-ridge from Tanks 1 & 2 (RHMW01), which leaves the aquifer source zone spatially uncharacterized. In other words, we know nothing definitive with respect to the LNAPL source zone except for evidence that it is in direct contact with the groundwater system.

PROPOSED APPROACH

The proposed LNAPL source zone approach here is founded on the relationship between the LNAPL and the dissolved-phase impacts it generates in groundwater, augmented with sequential conservative assumptions as needed in areas with no data. The main concept is to determine the maximum conservative extent of new LNAPL releases as a function of various release volumes derived from the Navy's work and as confirmed by our internal tank release experts. We can then determine which, if any, of these conservative expansion scenarios may result in a potential risk to groundwater receptors.

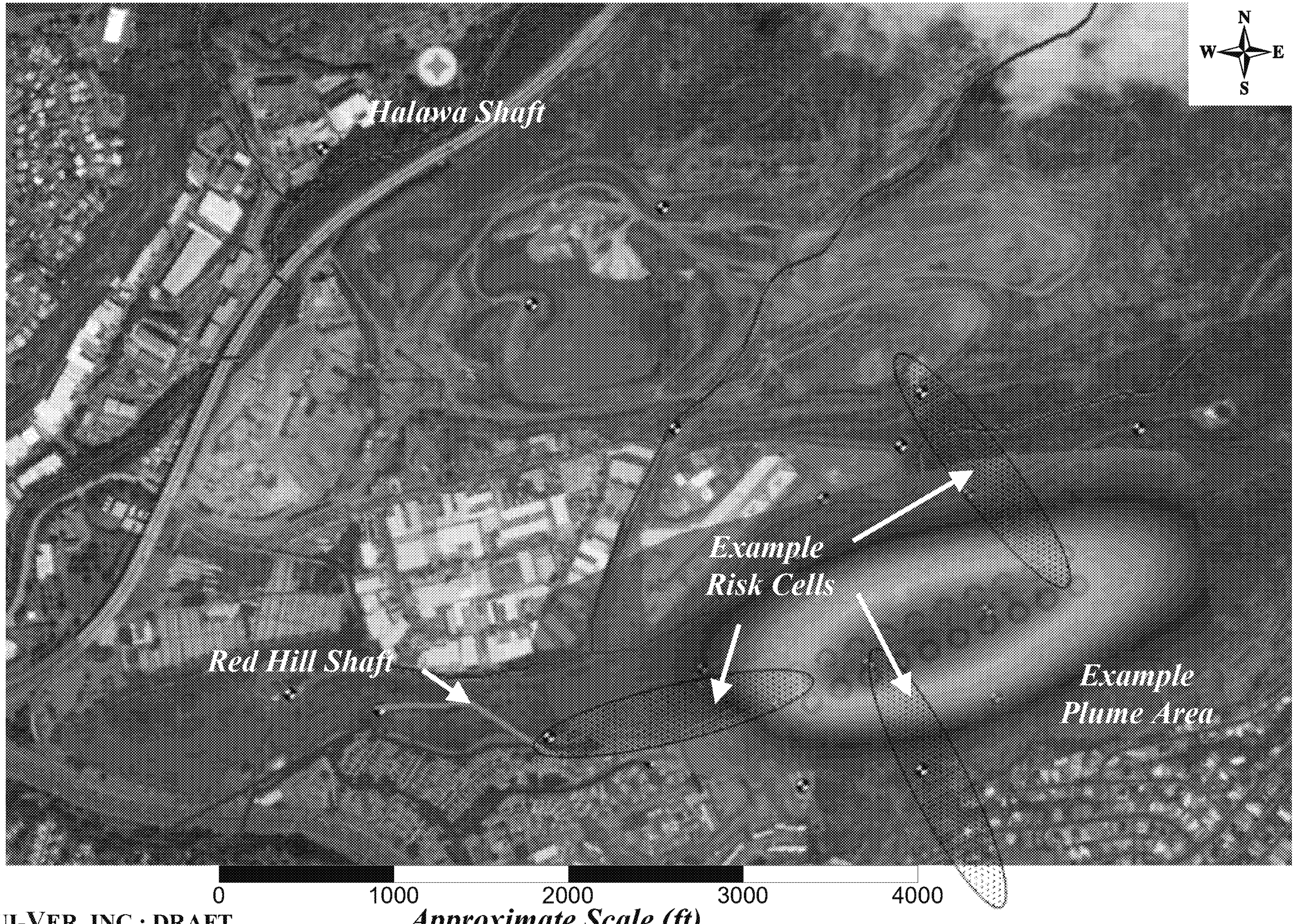
The sequence of LNAPL source term evaluations is as follows:

1. Evaluate all groundwater monitoring wells for potential fuel hydrocarbon impacts to determine the more likely than not condition for each, with the parametrics as follow:
   a. Have petroleum hydrocarbons consistent with jet and diesel been detected?
      i. If hydrocarbons have been detected, at what frequency and magnitude?
   b. Do biologic degradation indicators fall within a potentially impacted spectrum?
   c. Are there any exclusionary data or conditions that suggest false positives?
   d. Tally up the above matrix and determine if it is more likely than not that each well has or has not been impacted by fuel hydrocarbons in the past.
   e. All impacted wells can then be conservatively assumed to be within the boundary of potential past/present LNAPL impacts. Recall that Hilo had no hydrocarbon impacts even at the free product boundary but did exhibit dissolved-oxygen depletion in areas where impacts had been noted.
2. Step 1 above gives the area of conservative existing potential LNAPL impacts, next we need to determine the potential porous volume around the water table where LNAPL might reside.
   a. Use HSSM or MAGNAS to run some screening calculations of LNAPL water table geometry in a system dominated by low-capillarity void inter-connectivity (the conservative assumption). This will give the geometry of vertical distribution with distance away from a release area.
   b. Couple the above with a hydrograph analysis of several key wells to determine the range of variability of the water table and that will inform the potential smear zone vertical dimension. The smear zone will be thicker in the release area than distally.
   c. Given #1 & #2 bounding, the conservative water table smear-zone volume and distribution can now be estimated.
   d. The distribution above may be divided into individual areas that are associated with each tank or tank area, since the potential risks will differ depending on the tank locations. For instance, it is most likely that the risk to Red Hill Shaft will be greatest from releases at the down-ridge area of the Tank Farm (e.g., Tanks 1 - 4). Potential risks to the Halawa Shaft are more likely associated with upper-ridge tanks (Tanks 16 - 20); Figure 1 provides a rough example of this zonal approach.
3. We can conservatively assume that the source zone residual volume is at its capacity (i.e., can retain no new LNAPL additions) in the estimated existing smear zone. This is not representative, but it is clearly a conservative end-member that assumes past releases have been retained at near capacity. With this assumption, each future release will cumulatively expand the perimeter of the smear zone, but that perimeter is unimpacted before a new release and therefore it will have its residual capacity intact.
   a. Assume a range of residual capacity values based on known and best-estimate rock properties from site measurements, and as important, relevant basaltic hard-rock case studies to address the agency-noted deficiencies in the Navy's petrophysical testing.
   b. Determine the range of potential future releases based on the Navy's estimates and modified, as necessary, by our internal experts determinations. This is a critical component, as the nature/volume of the release is the driving mechanism for risk.
   c. Create a matrix of releases and new smear-zone volumes extended at the plume periphery and the associated proximity to receptors.

4. For a set of the worst-case potential plume expansions above, update the groundwater fate and transport estimates done previously to include the updated Navy CSM parameter values, along with adjunct information from Bob W. and Don T.
   a. Our expectation from past F&T modeling is that there will be no risk to any receptor located any further than about 200-ft from the LNAPL source zone perimeter. That may be even less once we account for potential dilution effects.
   b. From the above, determine whether or not there is any risk potential to these conservative end-member conditions. If there is no reasonable risk scenario, then no further work needs to be done.
   c. The ovoid form of the smear zone and the void-dominated geologic structure relative to transport suggests a high degree of potential dilution that will need to be considered both in terms of the LNAPL source zone, but in its buffering effect on flux/risk.
   d. Biodegradation will be assumed to be active in the groundwater transport zone and result in some level of attenuation between the LNAPL source and the receptors.
   e. If there are some scenarios where a potential risk to a receptor is generated, then the sensitivities resulting in that risk will be explored to provide insights into new potential data that may further refine the understanding of those conditions.

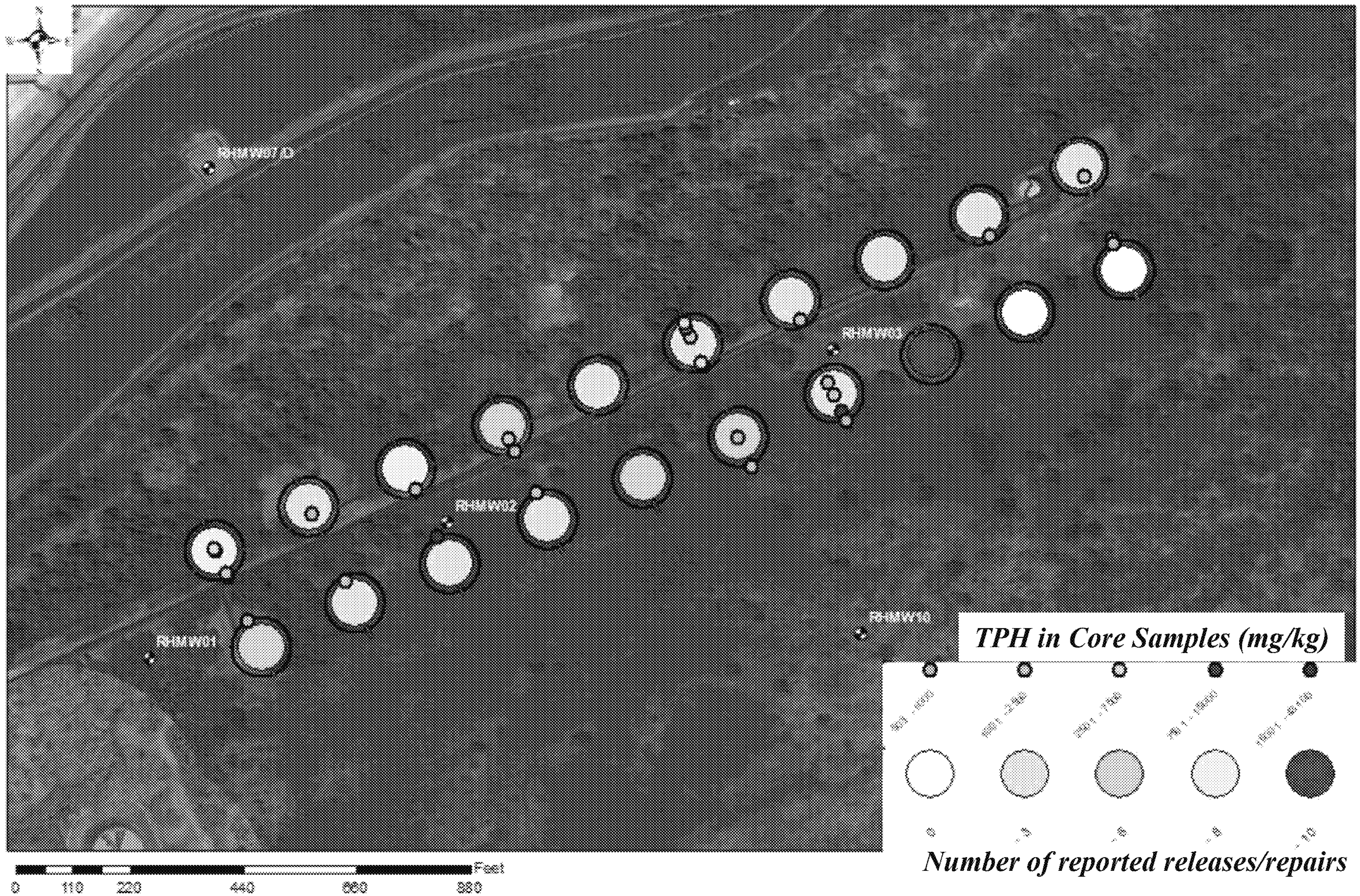
6871 North 2200 West, #8F Ph. 435 655-8024 FAX 435 655-8026

Figure 1: Example of LNAPL Risk Cells



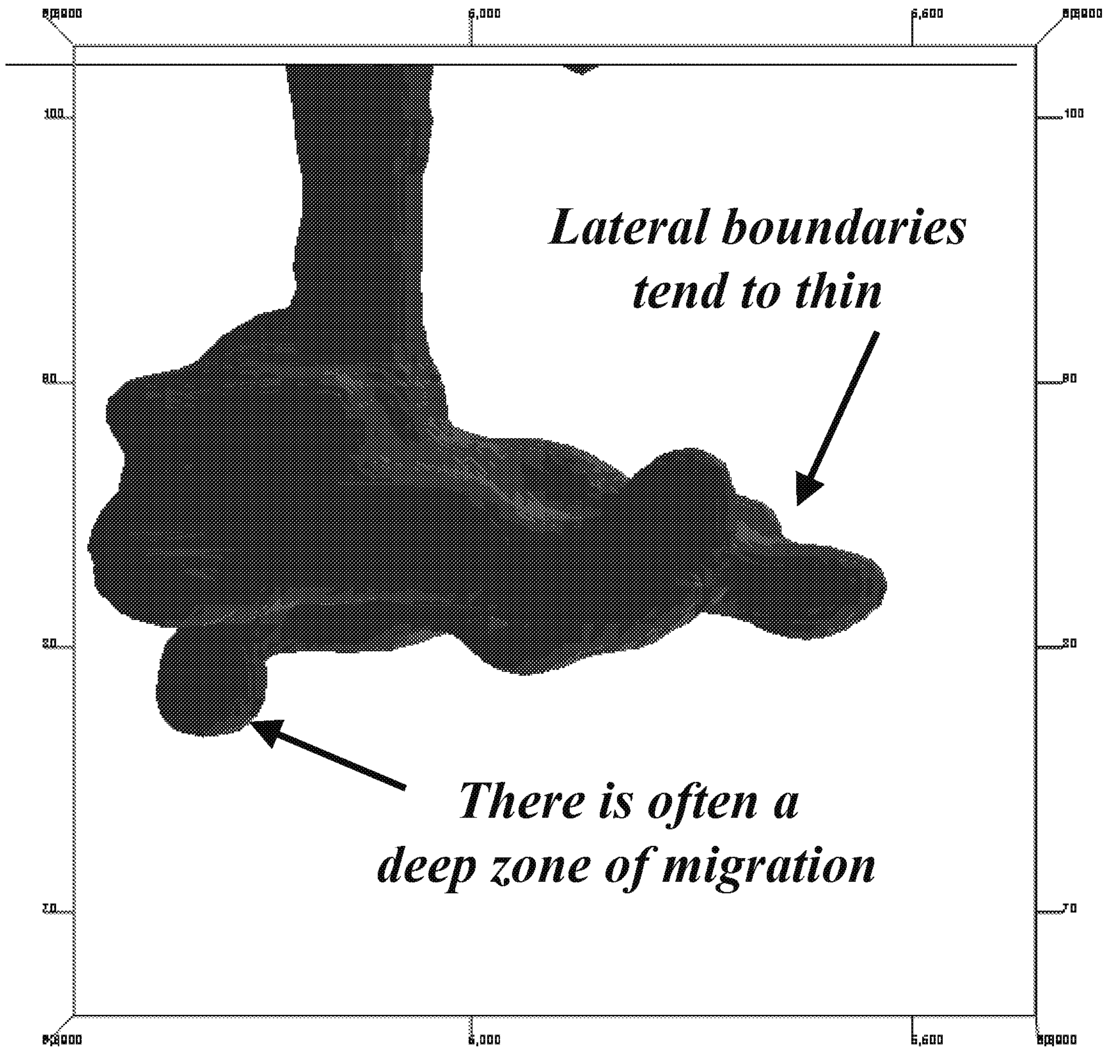
AQUI-VER, INC.: DRAFT

Figure 4
Reported Tank Releases & TPH Core Results



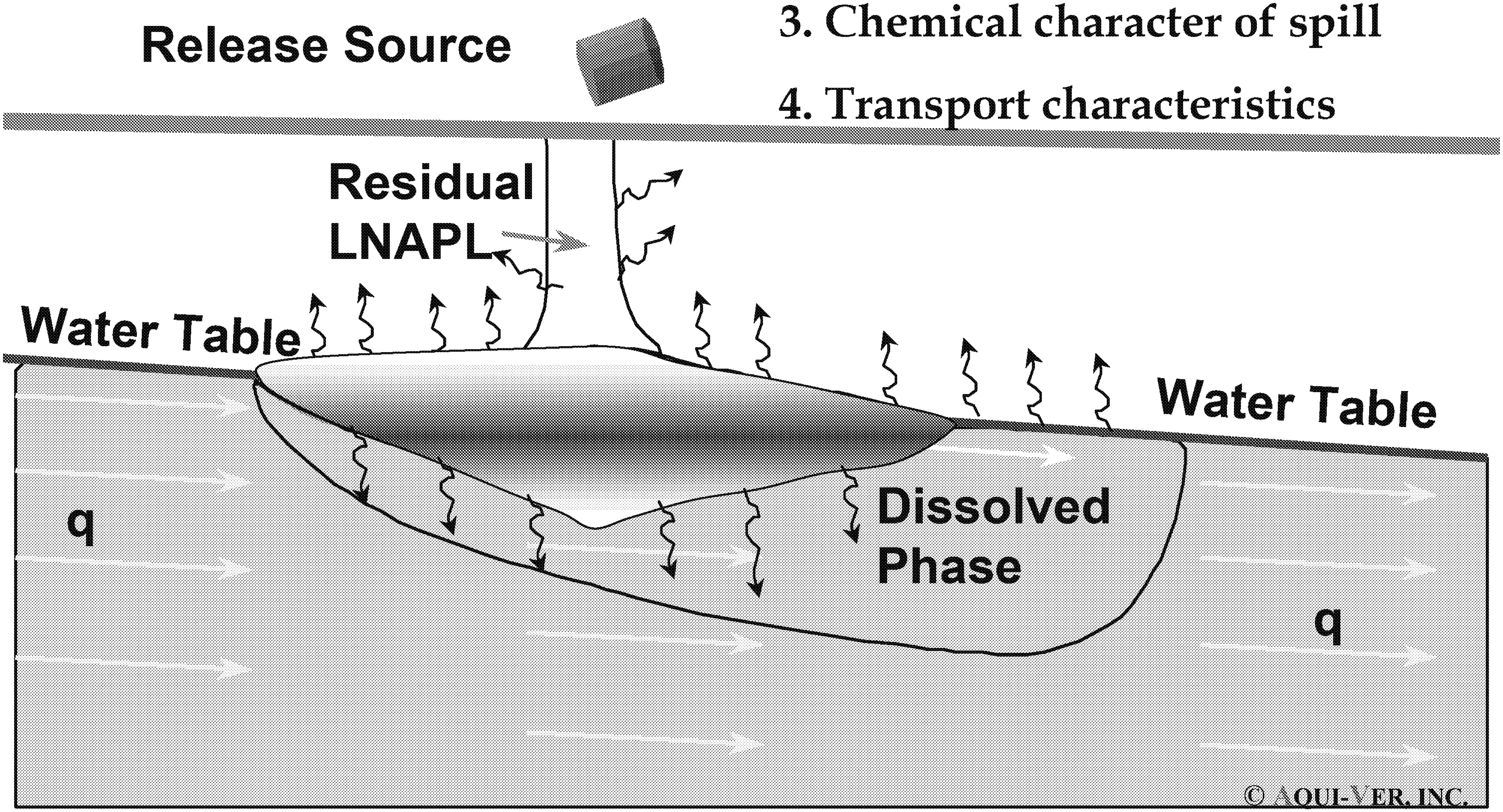
Example; Well-Defined LNAPL Source Zone

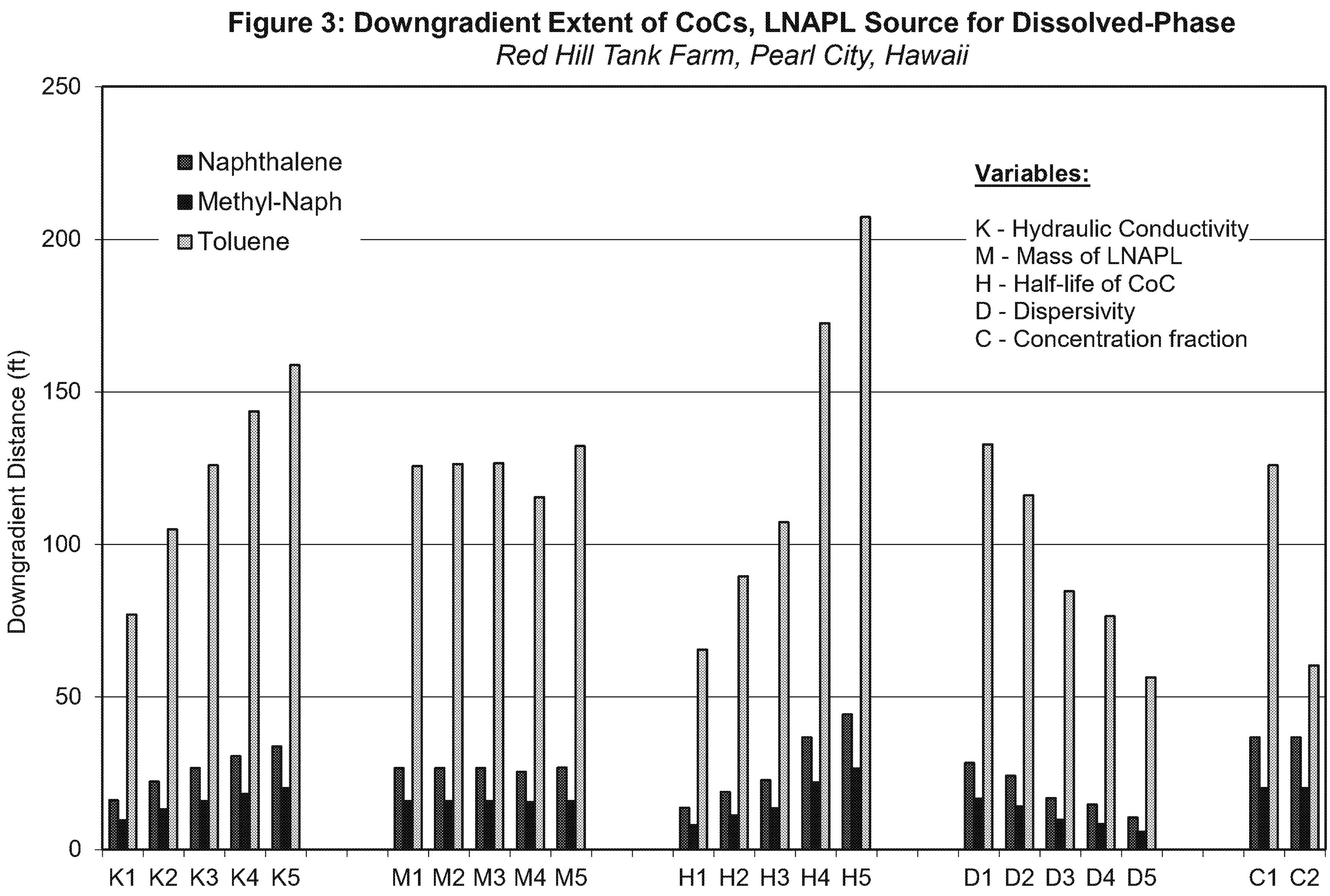
(LNAPL volume ~ 750k gallons)



Relationship Between LNAPL & Groundwater

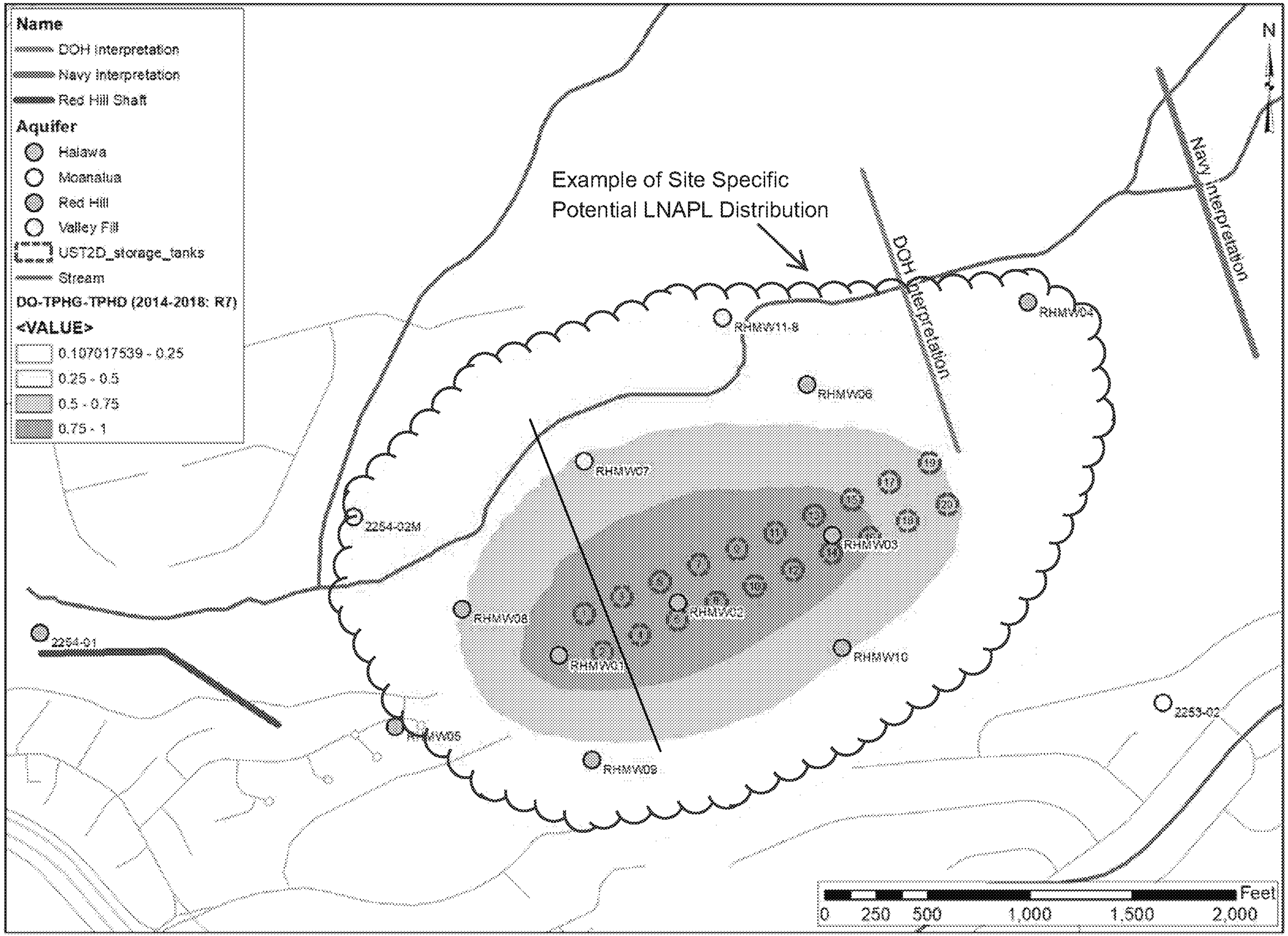
1. **Distribution of spill**
2. **Properties of the media**
3. **Chemical character of spill**
4. **Transport characteristics**





6871 North 2200 West # 8F Park City, UT 84098 Ph. 435 655-8024 Fax 435 655-8026

Figure 2
Cumulative Dissolved-Phase Impacts – Multifactor



DRAFT for Regulator Review and Discussion Purposes Only